

A CUMULATIVE SPECIES DESCRIPTION CURVE FOR LARGE OPEN WATER MARINE ANIMALS

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A cumulative species description curve (from 1830 to 1995) is given for open water marine fauna in excess of 2 m long in the major axis of the body. This curve has not yet closely approached its asymptote. Estimation by maximum likelihood fit of a hyperbola suggests a maximum of some 47 species awaiting formal scientific description and an approximate current rate of description of one new species every 5.3 years. Consideration of the most recently described species and recent observations by field workers suggests that any imminent species descriptions are most likely to be cetaceans.

Both marine biologists and the general public like to ponder on the existence of large unknown aquatic organisms. Yet conclusive evidence is not forthcoming for either the freshwater or marine members of this exclusive and elusive grouping (Campbell, 1991; Bright, 1989). Are there many new species awaiting discovery by science? Analysis of the discovery or description rate for known large marine animals can provide interesting insights into the chances of finding and describing, as yet, unknown fauna. Although there can be discrepancies (Pine, 1994), discovery and description dates can be reasonably assumed to be correlated and description more truly reflects recognition by science of a distinct species than mere discovery.

Thus description dates for large (defined as > 2 m in length/diameter in the main axis of the body) open water marine fauna from 1758 (from the 10th edition of the *Systema Naturae*, Linnaeus, 1758) to 1995 were collected from the scientific literature. The list included one cnidarian, six molluscs, one urochordate, 60 cartilaginous fishes, 52 bony fishes, four reptiles and 93 mammals. A plot of the species accumulation curve from 1830 (thus avoiding early lags between discovery and description) gave a fairly smooth curve (Figure 1). This curve has not yet closely approached its asymptote.

A hyperbola of the form (eqn 1) was fitted by the maximum likelihood method of Raaijmakers (1987; Colwell & Coddington, 1994; software: Henderson & Seaby 1997):

$$S_{(n)} = S_{max} - \left(\frac{BS_{(n)}}{n} \right) \quad (1)$$

where n is the sample number (with 1830 as year one), $S_{(n)}$ is the cumulative number of species described in the n th year since 1829, S_{max} is a constant, the estimated total number of species existing minus 101 (the cumulative species total in 1829) and B is a fitted constant.

This suggested a total of approximately 47 species awaiting description (by maximum likelihood estimation of S_{max} as 162.7) with an instantaneous rate of description in 1998 of 0.189 per annum (by substitution for S_{max} and B , rearrangement, differentiation and substitution for n), suggesting one new large open water species is discovered approximately every 5.3 years. As no meaningful error terms are widely accepted for this method (Colwell & Coddington, 1994), successive maximum likelihood estimates of the maximum number of species from the last 110 y (dotted curve in Figure 1) were calculated.

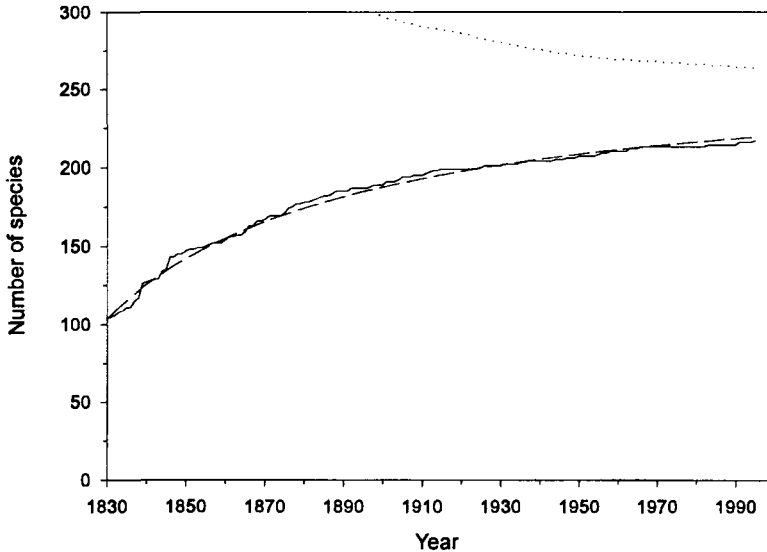


Figure 1. Number of described large open water fauna (>2m length/width) since 1830: (—), cumulative number of species described; (----), the expected cumulative number of species from the model; (....), successive estimates of the maximum number of species >2 m long.

Discovery curves are normally based on a constant sampling rate (Colwell & Coddington, 1994). This was definitely not the case here. If the sampling rate has effectively decreased in recent years with the decline in whaling and/or the decline in sailing vessels (possibly useful in catching acoustically sensitive large animals), then the method used here provides an underestimate of the total number of unknown animals awaiting discovery. However, it is more likely that the effective sampling rate has increased with increased numbers of marine research trips, more effective reporting of strandings and large scale pelagic netting. In this case then the analysis provides an upper limit for the total number of species awaiting discovery. The validity of the analysis presented here would also be in doubt if many new species are split from existing species by information gained by molecular techniques or new methods of biological sampling found large numbers of new species of large marine fauna in as yet unexplored habitats.

The most recent descriptions of more than 2 m marine fauna have been bony fishes (two since 1960), sharks (two generally recognized large species since 1960) and mammals (three generally recognized large species since 1960). As field observations suggest one or two species of odontocetes probably await capture and formal description (Jefferson et al., 1993) then this makes cetaceans seem the most likely candidates for any imminent species descriptions. However separate curves should be calculated for each major taxa to work out specific description rates. All the most recently described >2 m fauna have belonged to recognized families with the exception of the megamouth shark, *Megachasma pelagios* which although of a new family (Megachasmidae) was of known order (Lamniformes; Taylor et al., 1983) so the imminent discovery of wholly new extant orders would also seem unlikely although by no means impossible.

My thanks to P. Henderson for useful discussion and S. Walker, P. Le Blond and two anonymous referees for comments on the manuscript. I welcome details of any new open water large fauna. Only species generally recognized by science were utilized, e.g. not *Cadborosaurus willsi* Bousfield & Le Blond, 1995. I am also compiling the description dates of large freshwater fauna.

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